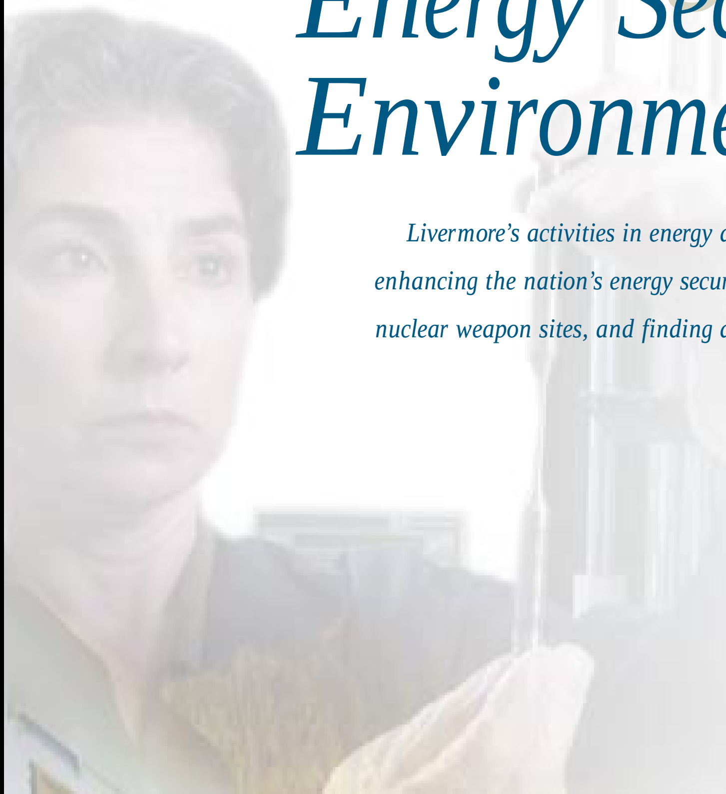
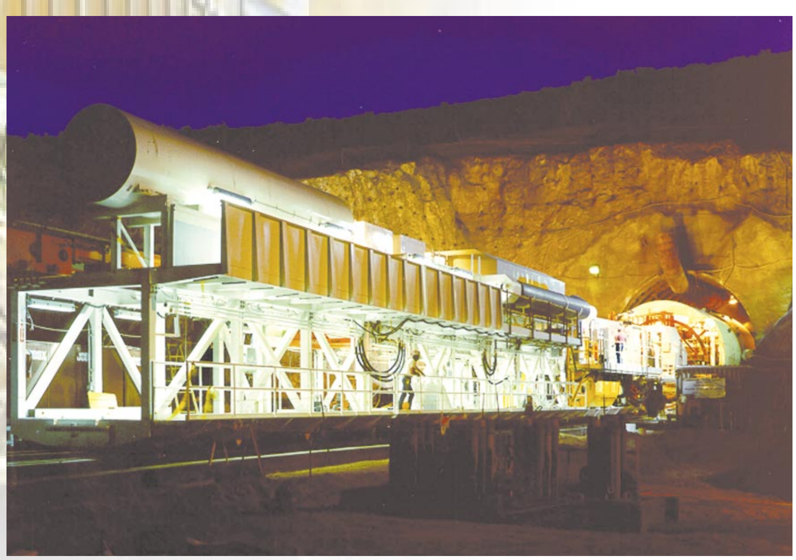
Breakthroughs in Energy Security and Environmental Management

Livermore's activities in energy and environmental science support DOE priorities, which include enhancing the nation's energy security, developing and making available clean energy, cleaning up former nuclear weapon sites, and finding a more effective and timely approach to nuclear waste disposal.



Our researchers are testing more than 20,000 specimens of candidate materials for packaging the waste in the proposed Yucca Mountain nuclear waste storage facility (below). Tests on samples, such as the one above at Livermore, help determine the materials' resistance to stress corrosion cracking.



Waste Storage for the Millennia

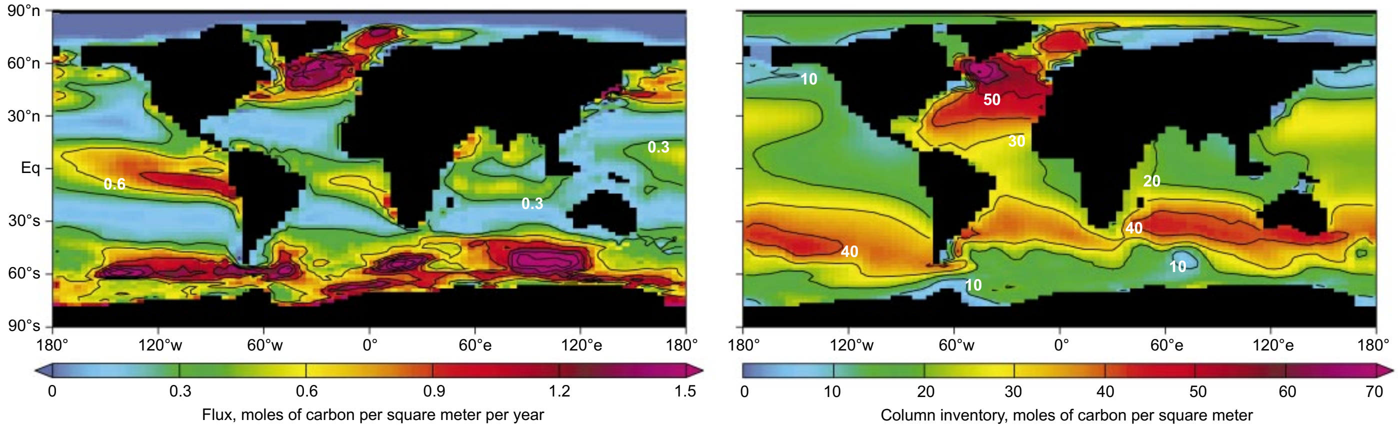
Yucca Mountain, at the Nevada Test Site, is the nation's candidate site for a high-level nuclear waste repository. The Laboratory is helping DOE to address some of the major scientific challenges in nuclear waste storage. We have been testing the materials for making waste storage containers to be buried in underground tunnels and researching the site's geology to accurately predict how the heat from buried nuclear wastes would affect the areas nearby. In particular, scientists need to know if geologic responses over thousands of years could cause the waste packages to corrode and spread radioactivity.

In 1999, we made major upgrades to NUFT, a code we developed for flow and transport, to model in unprecedented detail the likely evolution of the geochemistry and hydrology of the repository. The code now accounts for how chemical reactions modify rock fractures and pores and links the reactions to equations that describe the transport of heat and water. Preliminary results show that the code is a valuable tool for tracking the interplay of water, heat, carbon dioxide, and chemical reactions within the repository's naturally occurring fractured rock.

The complex code takes advantage of supercomputers designed for DOE's Accelerated Strategic Computing Initiative to solve formerly intractable scientific problems.

Carbon Dioxide Absorbed near Antarctica

When computer models first predicted what happens to carbon dioxide added to the atmosphere by humans, the



The cold water of the Southern Ocean soaks up carbon dioxide, similar to the way soft drinks absorb it (purple areas, left image). However, simulations show that the carbon dioxide does not stay there. The cold water moves north and sinks, and the carbon dioxide ends up in the subtropic Antarctic Convergence Zone (red areas, right image).

models showed that much of it was sponged up from the atmosphere and stored in the cold Southern Ocean surrounding Antarctica. But when the water was tested, no massive stockpile of carbon dioxide had accumulated.

With funding support from DOE and the National Aeronautics and Space Administration, Livermore researchers, who are part of a newly founded DOE Center for Research on Ocean Carbon Sequestration, found an explanation. Their results, published in the January 28, 2000, issue of *Science,* show that the cold water travels north and sinks into the deep subtropical ocean. Further modeling will be required to understand the net effect of global warming on sequestration of carbon dioxide in the Southern Ocean. A warmer ocean is less able to take carbon dioxide out of the air and store it, but an increased number of microscopic plants that use carbon dioxide could compensate.

Visalia Cleanup Continues Good Work

Using environmental remediation technologies developed at Livermore, a licensed industrial partner is cleaning up Southern California Edison Company's pole yard in Visalia, an original Superfund site. By November 1999, the hydrocarbons removed from the Visalia site totaled 1.2 million pounds. Dynamic underground stripping and hydrous pyrolysis/oxidation removed or destroyed in place an amount of contaminants that would have required more than a thousand years with traditional pump-and-treat cleanup, the kind used at the site since 1975.

New Twist on Ball Bearings

A Livermore inventor came up with a new type of bearing—a passive magnet bearing—that may last longer than ball bearings or other magnetic alternatives, such as long-running, low-maintenance machines located in remote places such as space.

A mechanical bearing stabilizes the rotor until it has reached a transition speed between a few hundred and few thousand revolutions per minute. Then the repulsion force of the magnetic bearing causes the rotor to levitate and center itself, resulting in lower energy and maintenance costs by eliminating friction. For the invention, Richard Post, a lifelong researcher in energy and transportation, was presented the Design and Engineering Award for 2000 by *Popular Mechanics*.

Fuel Cell Breakthrough

Livermore developed a solid oxide fuel cell (SOFC) with world-record power density. Using a proprietary (U.S. patent pending) low-cost manufacturing technology and cell design, we have obtained power densities for single cells as high as 1.4 watts per square centimeter at 800˚C. The very high efficiency of SOFCs—up to 70 percent—enables chemical energy to be converted into electricity with much less greenhouse gas emission compared to other power sources. Because our results were obtained using a symmetrical planar cell design, it should be possible to assemble fuel-cell stacks having similar power densities and much higher total power output. The Laboratory is looking to license the technology.